Injury, Int. J. Care Injured 46S4 (2015) S129–S134

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

One year orthopaedic trauma experience using an advanced interdisciplinary hybrid operating room

Peter H. Richter[a,*], Seth Yarboro[b], Michael Kraus[c], Florian Gebhard[a]

[a] Ulm University, Ulm, Germany
[b] University of Virginia; Charlottesville, Virginia, United States
[c] Donau-Ries Hospital Donauwörth; Donauwoerth, Germany

KEYWORDS

hybrid operating room
intraoperative imaging
3D imaging
navigation
computer assisted surgery

ABSTRACT

Hybrid operating rooms have been used successfully in several surgical specialties, but no data have been published for orthopaedic trauma. We present our one-year orthopaedic trauma experience using a hybrid operating room, which incorporates 3D fluoroscopic imaging as well as navigation capabilities. Data were compiled for a series of 92 cases performed in an advanced hybrid operating room at the level one trauma center in Ulm, Germany.

All patients who had surgery performed using this operating room during the first year were included. Setup time and surgical complications using hybrid operating room were recorded and analysed.

The hybrid operating room resulted in no higher rate of complication than expected from the same cases in a conventional operating room. The hybrid room did however allow the surgeon to confidently place implants for orthopaedic trauma cases, and was most advantageous for spine and pelvis cases, both minimally invasive and conventional. Further, appropriate reduction and implant position was confirmed with 3D imaging prior to leaving the operating room and obviated the need for postoperative CT scan. Based on our one-year experience, the hybrid operating room is a useful and safe tool for orthopaedic trauma surgery.

Introduction

In recent years, many surgical disciplines have developed minimally invasive procedures, which aim to decrease complication and improve recovery from the surgery. An advancement that has allowed this change is the improvement of intraoperative imaging and visualization [1-4]. Certain surgical specialties such as cardiothoracic and vascular surgery led the way to incorporate innovative imaging devices into the operating room. These devices define the hybrid operating room, where the imaging device is digitally linked to the operating table and can optionally be connected to other devices such as navigation [5-9].

Beginning June 2013, the University of Ulm began using an interdisciplinary hybrid operating room that employs a floor-based flat plate robotic C-arm with 3D scan capability (Artis Zeego, Siemens; Germany). This C-arm is capable of large volume 3D fluoroscopic scan. The navigation interface in our setup is accomplished through BrainLAB Curve (BrainLAB; Germany), which has been fully integrated to work with the Artis Zeego (Fig. 1). This combination represents an advanced imaging and navigation system, and it is the first of its type. Here, we present our experience from the first year using this system.

The equipment for the system is contained in a hybrid operating room that is 58.6 m² in size. The size of the server room is 10.79 m². The 12.32 m² technical support room is connected and incorporates a viewing window.

The surgeon controls the robotic C-arm through a sterile control panel that attaches to the table, and an optional foot pedal provides further control (Fig. 2). The flat plate C-arm has the advantage of a wide field, allowing the entire lumbar spine, pelvic ring, or long bone to be seen in a single view (Fig. 3).

Further, the view results in a large volume 3D fluoroscopic scan, making appropriate positioning easier to achieve. The advantage of this setup that is immediately apparent is image quality. The resolution on the large screen monitor is 4 times greater than standard high definition, and with the collimation feature of the C-arm, excellent contrast and definition is easily achieved, even in obese or osteopenic patients. With a contrast resolution of up to 3-5 HU, compared to a conventional CT scanner with a resolution of up to 1 HU, the Artis Zeego system enables a great soft-tissue visualization. After sending imaging data to the navigation system, the intraoperative 3D scan can be merged with a preoperative MRI. Particularly in orthopaedic oncologic surgery, the merging of different image sources can be a significant advantage to ensure complete tumor resection.

The orthopaedic trauma department has used this system mostly for pelvic and spinal surgery, including both trauma and oncologic indications. A complete list of cases can be seen in Table 1. From an interdisciplinary standpoint, the operating

* Corresponding author at: Albert-Einstein-Allee 23, 89081 Ulm, Germany. Tel.: +49-731-500-54567; fax.: +49-731-500-54502.
E-mail address: Peter.richter@uniklinik-ulm.de (Peter H. Richter).

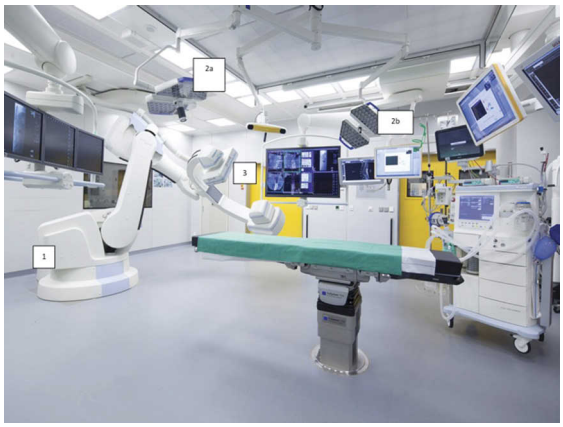

Fig. 1. Hybrid operating theater at the Surgical Department of Ulm University in Ulm, Germany. The robotic 3D C-arm (1) is connected to the operating table and to the navigation system (2a: camera; 2b: control screen). The intraoperative images are visualized on the large display (3).

Fig. 2. Control panel of the c-arm. The system is able to be completely controlled by the surgeon.

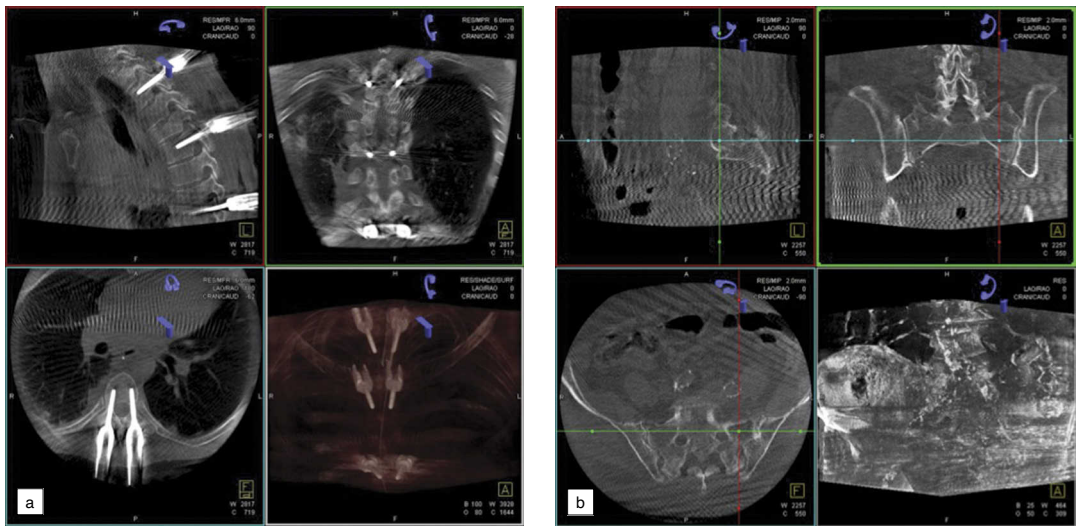

Fig. 3. This figure shows the large field of view and high image quality. Eight thoracic vertebra can be displayed with a single intraoperative fluoroscopic 3D scan. There is minimal artifact even with implanted pedicle screws (3a). One 3D-scan is enough to display the entire pelvis. Sacral insufficiency fractures can be seen on both sides (3b).

Table 1
Cases performed in hybrid OR.

Posterior stabilization of spine	58
Sacroiliac screw placement	12
Implant removal	7
ORIF extremity	5
Vertebroplasty/kyphoplasty	5
Biopsy	5
Tumor resection	4
ORIF acetabulum	3
Osteochondral lesion drilling	2
Cervical fusion	2
Odontoid screw	1

room is shared between orthopaedics, neurosurgery, cardiothoracic surgery, and vascular surgery. Allocation for use of the room is discussed at regular intervals, and at present at our institution, the orthopaedic trauma department uses the room two days per week. The other disciplines use it one day each per week.

Case examples

Case 1

A 51-year old male was admitted after a fall from a roof. He was found to have a fracture of the right acetabulum (Fig. 4a). He elected to proceed with minimally invasive internal fixation using navigation. Fig. 4b shows the high quality image of the 3D C-arm with minimal artifact. The intraoperative 3D scan (Fig. 4b) and the postoperative x-ray (Fig. 4c) show appropriate reduction and screw placement. The intraoperative scan obviates the need for postoperative CT scan, and implant position is confirmed prior to leaving the operating room.

Case 2

A 51-year old male fell from his mountain bike and broke his first cervical vertebra (Fig. 5a). Because of fracture instability and displacement, stabilization of C1-C2 was performed. After placement of the first screw and working with the awl on the other side, there was a large amount of bleeding. To exclude a damage of the vertebral artery an intraoperative angiography could be done by the neurosurgeons immediately to rule out vascular injury without the need for patient movement (Fig. 5b).